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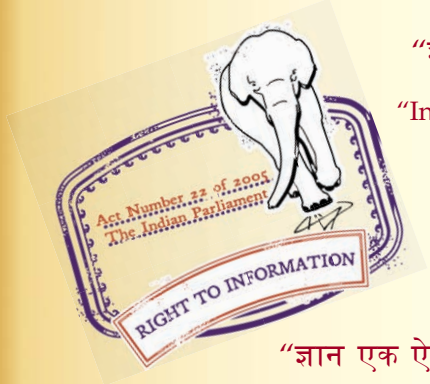
IS 11875 (1986): Diffuse Pyranometer [PGD 21: Meteorological Instruments]

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"Knowledge is such a treasure which cannot be stolen"

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IS : 11875 - 1986



# *Indian Standard*
# SPECIFICATION FOR DIFFUSE PYRANOMETER

UDC 551·508·26 : 536·521·2



BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 4 *August* 1987

# *Indian Standard*

## SPECIFICATION FOR DIFFUSE PYRANOMETER

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*Shri N. Seshadri was the Chairman for the meeting in which this standard was finalized.

# AMENDMENT NO. 1 MAY 1994
# TO
# IS 11875 :1986 SPECIFICATION FOR DIFFUSE PYRANOMETER

( *Page* 2, *clause* **0.2** ) — Substitute the following for the existing first sentence:

'Diffuse solar irradiation is the component of solar irradiance which is scattered diffusedly by the atmosphere and other suspended particles including clouds.'

( *Page* 10, *clause* **5.1.4**, *line* 2 ) — Substitute '0.3 to 50 μm' *for* '0.3 μ to 50 μ'.

( *Page* 10, *clause* **5.1.5**, *line* 3 ) — Substitute '11 $\mu VW^{-1}m^{-2}$' *for* '11/μV/W/$m^2$'.

[ *Page* 14, *clause* **7.1.2** (b) ] — Substitute 'μV' *for* 'uV'.

'Note — Substitute 'per cent' for 'percent' wherever it appears in the standard.'

(LMD 21)

Reprography Unit, BIS, New Delhi, India

# *Indian Standard*

# SPECIFICATION FOR DIFFUSE PYRANOMETER

## 0. FOREWORD

**0.1** This Indian Standard was adopted by the Indian Standards Institution on 14 September 1986, after the draft finalized by the Meteorological Instruments Sectional Committee had been approved by the Mechanical Engineering Division Council.

**0.2** Diffuse solar ( sky ) radiation is the shortwave energy component of Solar Origin — scattered and diffused downwards by the gas molecules, water vapour, dust particles and clouds present in the atmosphere. It varies markedly from day to day and hour to hour ( even at the same place ) with the change in solar elevation, the apparent position of the Sun in the sky, the latitude and altitude of the place, the degree of atmospheric turbidity, the amount of water vapour content and the most predominant factor being the type and degree of cloudiness. Radiation climatology of a region depends essentially on all the components of radiant energy received, including diffuse ( sky ) radiation — the study of which is important in fields like building research, solar energy utilisation, interior illumination and architecture.

**0.3** The most widely used of the principal instruments for the measurement of diffuse ( sky ) radiation is the thermoelectric pyranometer described in IS : 8336-1977, used in conjunction with a shading ring or disc to screen off the direct incident radiation from the sun reaching the sensor. While the measurement with the former needs to be corrected for the appreciable masking of diffuse radiation from the sky by the width of ring, the latter presents greater difficulty in obtaining exact synchronised movement of the disc with the sun's apparent diurnal motion and often leads to erroneous date.

**0.4** For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off values should be the same as that of the specified value in this standard.

## 1. SCOPE

**1.1** This standard prescribes the requirements for a thermoelectric pyranometer, shading ring attachment assembly and a suitable recorder with charts for use with it.

*Rules for rounding off numerical values ( *revised* ).

**1.2** The shading disc along with ancillary arrangements for heliostat for precise synchronous movement with the sun is excluded from this standard.

## 2. DESCRIPTION

**2.1** The thermopile consists of a series of copper-constantan thermojunctions formed by winding constantan wire on a clear acrylic disc and plating half of each turn of the winding with copper. The junctions on the upper surface of the disc from the active or hot junctions while those on the lower form the cold junctions ( *see* Fig. 1 ). The upper surface is covered with an aluminium foil which is electrically insulated from the junctions by a very thin layer of epoxy resin cement, but is in good thermal contact with the active junctions. The passive or cold junctions are in good thermal contact with, but electrically insulated from, the massive base of the instrument. The active junctions exposed to radiation get heated while the passive junctions remain at ambient air temperature. By making the case massive and the outer surface painted matt white, the temperature is kept uniform. The sensitive surface, painted black by special optical black lacquer is protected by two concentric hemispherical glass domes, from wind and rain; they also reduce the tendency to form convection currents. The thermo-junctions, as a result of their difference in temperature, generate an electromotive force which is measured on a suitable millivoltmeter having the desired range and accuracy.

**2.2** The Schuepp model shading ring assembly ( Fig. 4 ) consisting of aluminium strip 51 mm wide bent to form a semi-circular arc of radius 450 mm is fitted to two sliders at both ends capable of sliding together inside longitudinal slots provided on each of the two arms with adjustable aluminium scale ( Solar declination ) ( *see* Fig. 5 ) fitted on them and pivoted centrally about a horizontal axis on the opposite sides of the rectangular 50 mm aluminium — angle frame 35 cm × 80 cm. The angle of tilt of the arms can be adjusted and read with the help of two slotted circular — arc ( latitude ) scales ( *see* Fig. 5 ) fitted on the rectangular frame.

To the bottom of the frame is fitted a iron plate 3 mm thick with 4 disjointed circular slots to permit azimuth orientation of the frame when fixed to 4 foundation bolts on the masonry platform. Another aluminium plate, 3 mm thick with 4 holes at appropriate position for mounting the pyranometer base, is fitted on the top of the frame.

## 3. MATERIAL

**3.1** The entire instrument shall be made of brass, unless otherwise specified.

**3.2** The sensitive element shall be made of 0·19 mm thick constantan wire, part of which is plated with copper and wound over a clear acrylic disc as shown in Fig. 1.

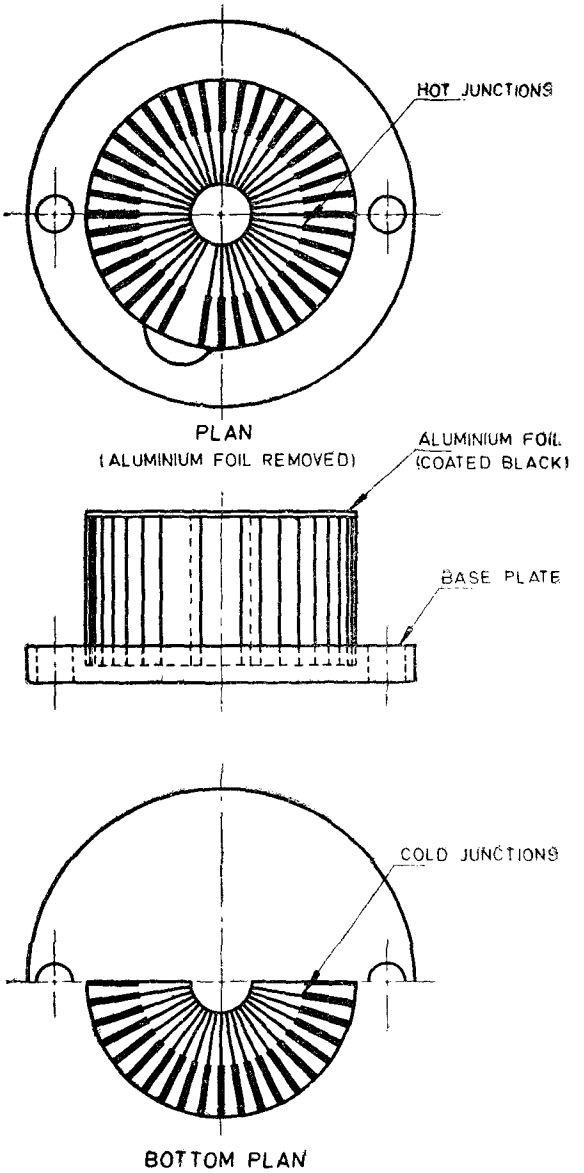



FIG. 1 THERMOPILE FOR THERMOELECTRIC PYRANOMETER

3.3 The protective domes shall be made of special, optically clear flint glass.

3.4 The materials used throughout shall be resistant to the corrosive effects of damp air, specially near the sea.

3.5 The shading ring shall be made from 2·8 mm thick good quality aluminium.

3.6 The frame shall be made from 50 mm aluminium angle.

3.7 The bottom and top plates of the frame shall be made from good quality aluminium and brass respectively.

3.8 The declination and latitude scales shall be made from good quality aluminium and brass respectively.

3.9 All the bolts and nuts for fixing pyranometer, its mount and the bottom plate of the frame of the shading ring assembly shall be made out of good quality brass.

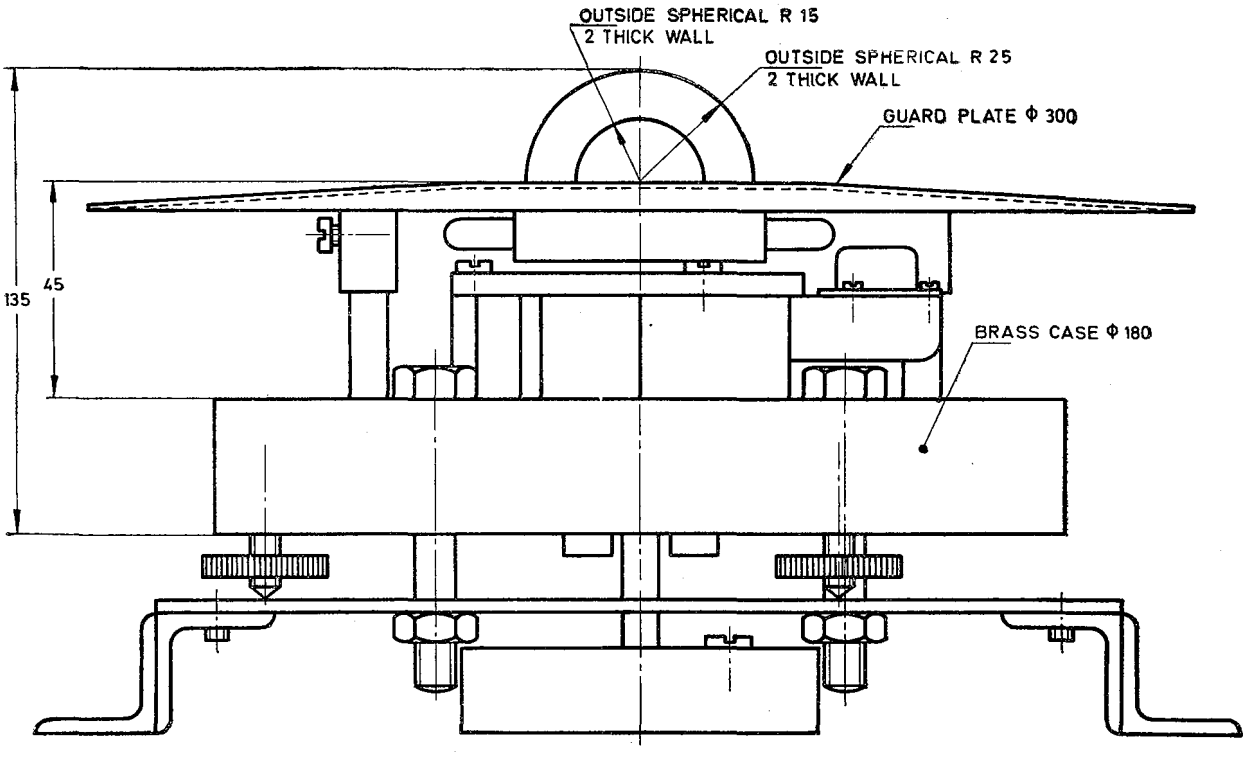
## 4. DIMENSIONS

4.1 The instrument shall have the dimensions indicated in Table 1 read with Fig. 2 and 3.

TABLE 1 DIMENSIONS OF PYRANOMETER

| COMPONENT | DIMENSIONS mm |
|---|---|
| External diameter of outer glass dome | 50 |
| External diameter of inner glass dome | 30 |
| Thickness of the glass domes | 2 |
| Guard plate | $\phi$ 300 × 1·5 |
| Central hole in guard plate | 55 |
| Diameter of brass case | 180 |
| Overall height ( without mounting plate ) | 135 |
| Height of guard plate above mounting plate | 90 |
| Height of guard plate above brass case | 45 |

4.2 The shading ring assembly shall have dimensions as indicated in Fig. 4 and 5.




All dimensions in millimetres.

FIG. 2 DIMENSIONS FOR THERMOELECTRIC PYRANOMETER

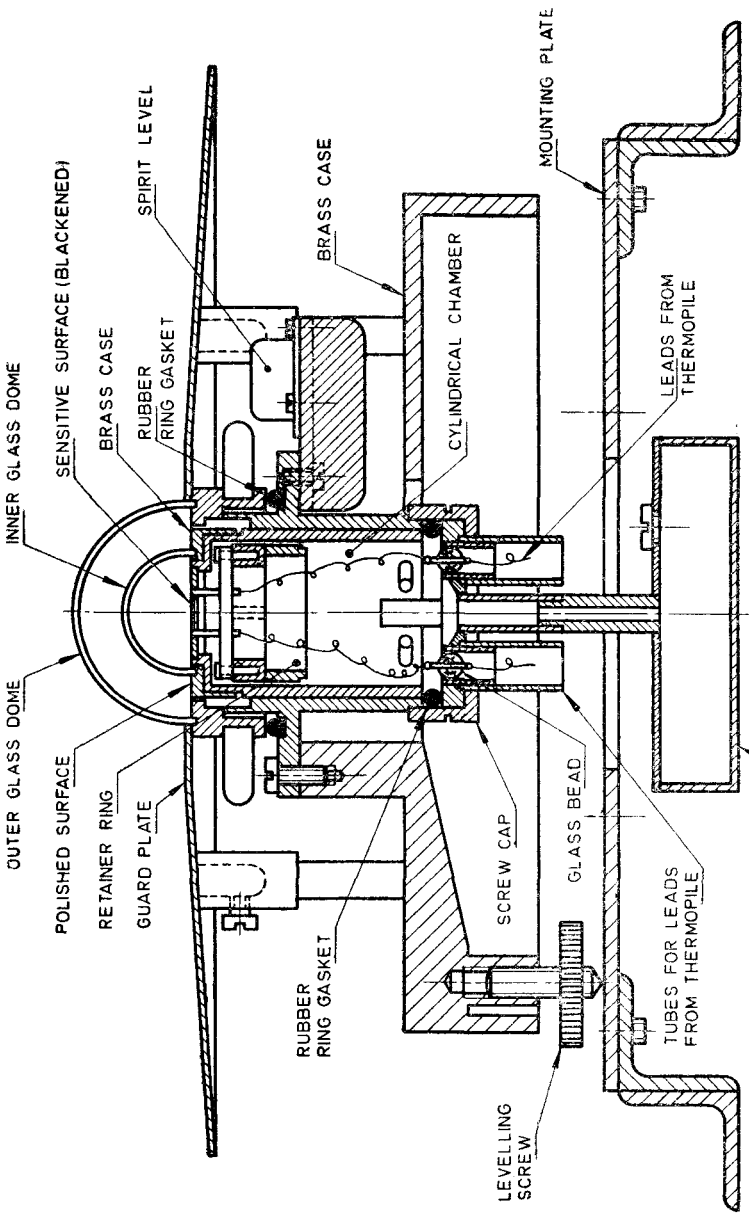
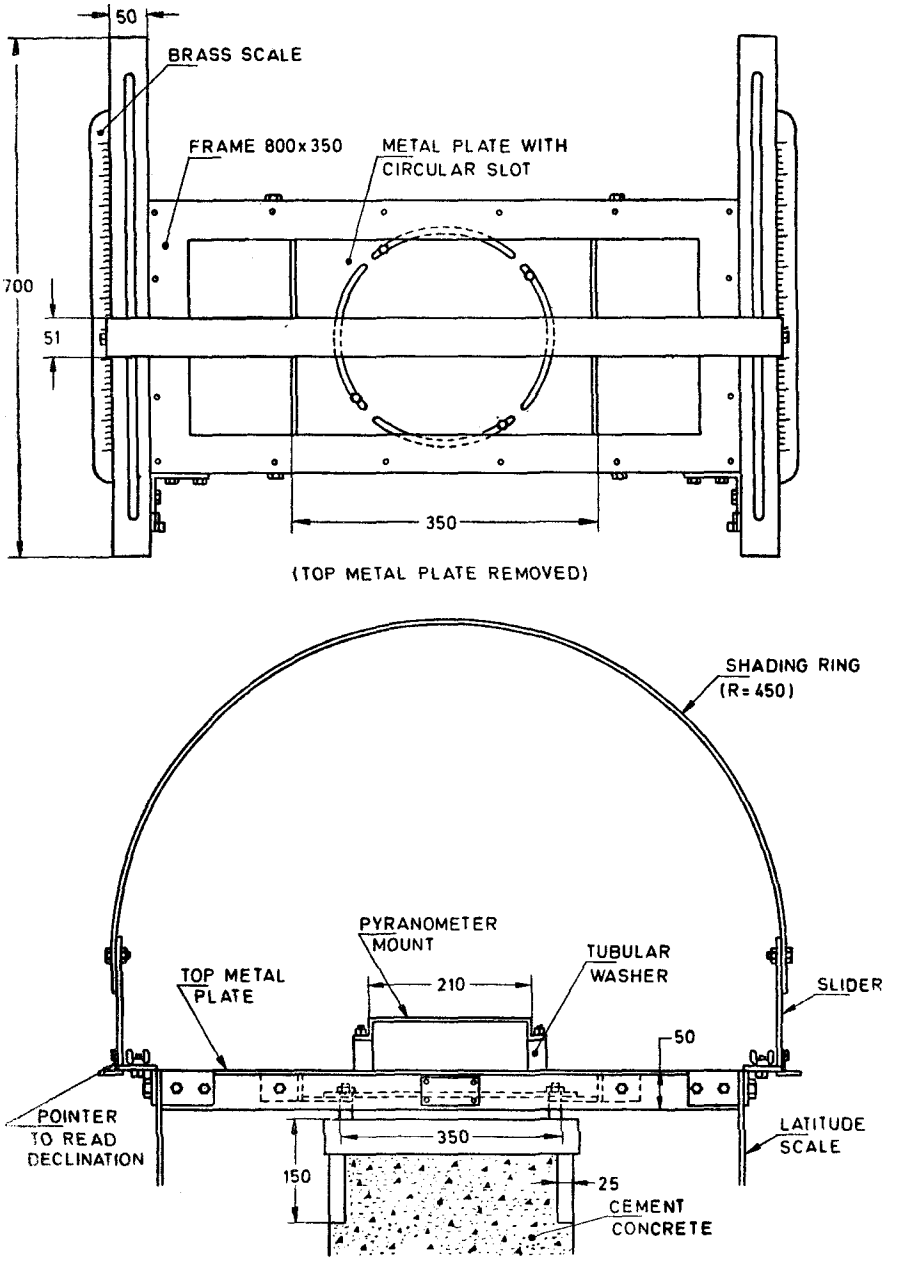
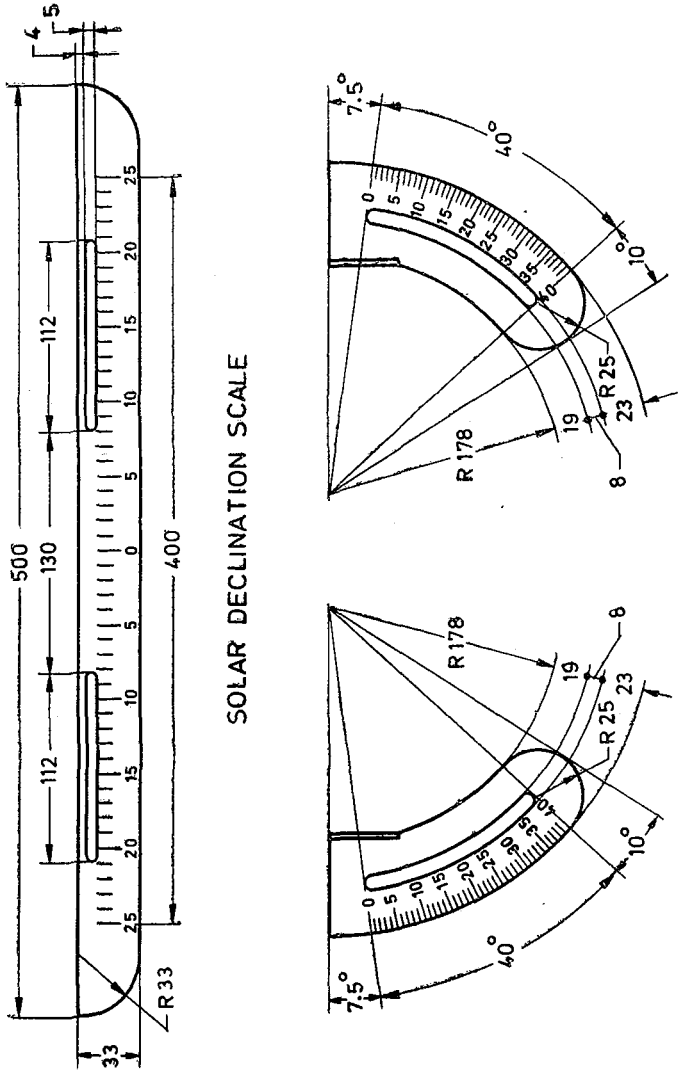



FIG. 3 SECTIONAL DETAIL OF THERMOELECTRIC PYRANOMETER




All dimensions in millimetres.

FIG. 4 DETAILS OF SHADING RING IN POSITION




All dimensions in millimetres.

FIG. 5 DIMENSIONS FOR SOLAR DECLINATION AND LATITUDE SCALES FOR SHADING RING

## 5. DETAILED REQUIREMENTS

**5.1** Pyranometer ( *see* Fig. 3 ).

**5.1.1** The glass domes shall be truly hemispherical in shape. They shall be made of special flint glass of exceptional clarity, uniform optical transmission characteristics and refractive index.

**5.1.2** The sensitive element shall consist of 39 active and passive copper constantan junctions formed on an insulating disc, approximately 20 mm in diameter and 8 mm thick. The thermopile should be made from 0·19 mm thick constantan wire.

**5.1.3** The active junctions of the thermopile shall lie in an even horizontal plane and painted black with special optical black lacquer.

**5.1.4** The absorptivity of the black lacquer shall not be less than 98 percent and uniform over a wide range of wavelength covering 0·3$\mu$ to 50$\mu$.

**5.1.5** The sensitivity of the instrument, that is, the smallest change in the quantity being measured which may be detected by it, shall be $\pm$ 3·0 W/m$^2$ and the output 11/$\mu$V/W/m$^2$, the total resistance with the connecting leads being 15 ohms.

**5.1.6** The stability of the calibration factor, that is, the maximum permissible change in this factor in a year shall not exceed $\pm$ 2 percent.

**5.1.7** The maximum error due to variation in ambient temperature shall not exceed —0·2 percent per °C.

**5.1.8** The maximum error caused by a departure from the assumed spectral response of the receiving surface shall not exceed $\pm$ 1 percent.

**5.1.9** The maximum error due to non-linearity of the response of the instrument shall not exceed $\pm$ 1 percent.

**5.1.10** The time constant of the instrument, that is, the time necessary for it to register 98 percent of a sudden change in radiation shall not exceed 30 seconds.

**5.1.11** The cosine response and the azimuth response, that is, the deviation of the directional response of the receiver from that assumed shall be within $\pm$ 3 percent.

**5.1.12** The entire instrument, except for the two glass domes, shall be protected from direct radiation by mounting it in the centre of a circular guard plate, 300 mm in diameter and painted white. The top surface of guard plate shall be exactly level with the blackened surface of the thermopile for a distance of 25 mm from the inner edge and shall slope down from there at an angle of about 10°.

**5.1.13** The electrical leads from the thermopile shall be mounted airtight inside the tubes through which they emerge and the screw cap closing the bottom lid of the cylindrical chamber shall be threaded over a rubber ring washer. The interior of the cylindrical chamber shall be connected to a vessel containing a dehydrating agent like silica gel such that the chamber is airtight and dry at all times.

**5.1.14** The entire instrument shall be mounted over a mounting plate approximately 210 × 210 × 5 mm also painted white. The mounting plate shall be provided with a number of small holes of 10 mm diameter drilled on the periphery of a circle of diameter approximately 105 mm for ease of installation and correct alignment.

**5.1.15** Both pairs of the sliders ( latitude and declination adjusters ) in the shading ring assembly shall have a pointer each and suitable arrangements for fixing it at any position on the scale.

**5.1.16** Engraving on both the scales shall conform to Fig. 5.

### 5.2 Recorder

**5.2.1** The recorder shall be of the potentiometric type and be provided with an arrangement which gives a continuous record on a roll chart.

**5.2.2** The method of recording shall be through a capillary pen writing with ink on paper.

**5.2.3** The chart drive of the recorder shall be operated by an electrically driven motor. The speed shall be at least 30 mm/h.

Provision shall be made for varying the chart speed up to 150 mm/h.

**5.2.4** The recorder shall have a range of 0 to 15 mV and an accuracy of ± 1 percent. It shall a threshold sensitivity of ± 0·1 percent.

**5.2.5** The measuring circuit of the recorder shall have the temperature co-efficient as near to zero as possible and the total errors of the recording apparatus shall not exceed ± 1 percent.

### 5.3 Recorder Chart

**5.3.1** The chart shall be of the roll type indicated in Fig. 6 and designated RP 1.

**5.3.2** It shall have a minimum length of 15 m and a minimum width of 120 mm in the graduated portion. The overall width of the roll chart shall be not less than 140 mm.

**5.3.3** It shall be divided along its width into at least 100 equal divisions with every fifth division slightly thickened and every tenth division more

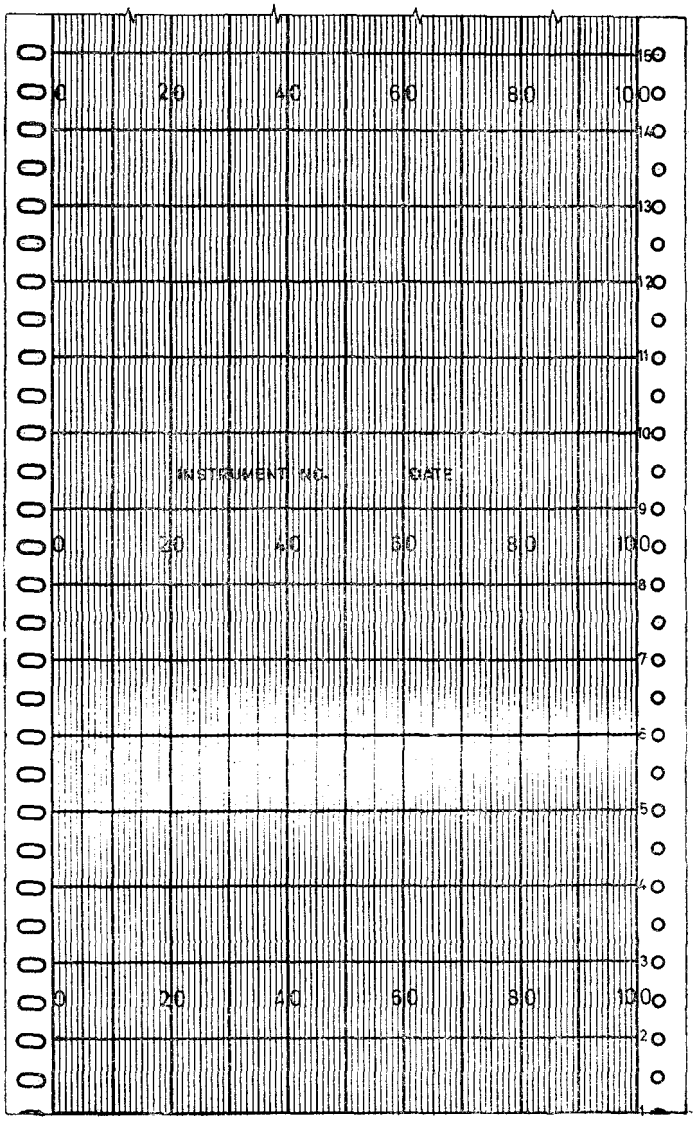



FIG. 6 RECORDER CHART RP 1

prominently thickened. It shall have printed on it vertical lines corresponding to hours, the time scale being equal to at least 30 mm/h. Each hour line shall appropriately be figured. The lines shall be figured at intervals of 20 divisions, the set of figures being space 200 mm apart.

**5.3.4** The chart shall be printed on thin white paper on which the recording ink shall not spread or show tendency to feather.

## 6. WORKMANSHIP AND FINISH

**6.1** The glass domes of the pyranometer shall be absolutely clear, clean and well polished.

**6.2** The complete instrument in the final stage of assembly shall satisfy the requirements laid down for it in **5.1.**

**6.3** Special care shall be given to make the interior of the instrument airtight and dry to ensure longivity and sensitivity of the sensing element. It shall be ensured that moisture does not reach the leads from the thermopile.

**6.4** The connections of the wires shall be made neatly using minimum amount of solder while at the same time ensuring strength and permanence of contact. The electrical junctions shall be suitably protected by glass fibre sleevings and wax coating to prevent malfunctioning of the electrical circuit due to high humidity and presence of water vapour.

**6.5** The entire instrument except the glass domes and the thermopile shall be painted white with two coats of good quality enamel paint over a coat of primer.

**6.6** The top surface of the instrument case between the two glass domes shall be highly polished to reduce the absorption of radiation. The levelling screws shall be nickel plated.

**6.7** The inner surface of the shading ring shall be painted matt black.

**6.8** The outer surface of the shading ring and the rest of the assembly shall be painted bright white.

**6.9** The anodised aluminium declination scale shall be neatly and accurately engraved.

**6.10** The brightly chromium plated brass latitude scales shall be neatly and accurately engraved.

**6.11** Markings on both types of the scales shall be filled with permanent black pigment.

## 7. MARKING AND PACKING

### 7.1 Marking

**7.1.1** Each pyranometer shall have the following neatly and legibly engraved on a plate fixed to the brass case.

a) Thermoelectric pyranometer;

b) The manufacturer's name or trade-mark, if any; and

c) The serial number and year of manufacture.

**7.1.2** The complete equipment shall also be provided with a card giving the following information.

a) The resistance of the thermopile,

b) The output of the pyranometer in uV/W/m$^2$, and

c) Range and accuracy of the potentionmetric recorder.

**7.1.3** The instrument may also be marked with the Standard Mark.

NOTE — The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act 1986 and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers, may be obtained from the Bureau of Indian Standards.

### 7.2 Packing

**7.2.1** The pyranometer and the recorder shall suitably packed separately as agreed to between the purchaser and the manufacturer. Each instrument set shall be supplied with sufficient quantity of suitable charts wrapped in waterproof paper to last about 12 months.

**7.2.2** The shading ring assembly shall be dismantled and packed suitably to avoid damage to the constituent parts and paints in transit.

**7.2.3** Extra care shall be exercised while packing the scales separately to avoid damage or deformation in transit.

**7.2.4** The semi-circular shading ring shall be packed separately and securely to avoid damage or deformation in transit.

## 8. INSPECTION

**8.1** Each pyranometer, recorder with charts and the shading ring assembly shall be inspected individually for conformity to all the requirements of this specification.

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Printed at Delhi Printers, Delhi, India